affects mycelial growth rate, fruiting stability, contamination resistance, spore yield, and the accumulation of active components such as polysaccharides and triterpenoids. With the continuous increase in market demand, *G. lucidum* production has gradually shifted from simply pursuing high yield to multi-objective breeding that considers high yield, superior quality, disease resistance, stable active component accumulation, and adaptability to facility-based management. Studies have shown that the mutant strain UV119 obtained through ultraviolet mutagenesis had a basidiospore yield 19.27% higher than that of the parent strain and 20.56% higher than that of the major commercial cultivar "Longzhi No. 1," while its fruiting body yield and contamination resistance were also improved (Tang et al., 2023). Another radiation-induced mutant strain, XZ-2, showed 9.7%~30.1% higher fruiting body yields and 20.2%~45.7% higher basidiospore yields than control varieties across multiple locations, while also exhibiting stable annual yields and relatively high polysaccharide and triterpenoid contents. These results indicate that superior variety breeding can directly improve the stability and industrial value of facility-based *G. lucidum* production.

In the breeding process, traditional breeding techniques should be combined with modern biotechnologies to systematically screen and evaluate *G. lucidum* genetic resources. Through strain isolation, basidiospore-derived monokaryon crossing, mutation breeding, molecular-assisted screening, and metabolomic evaluation, new *G. lucidum* varieties adapted to different regions and cultivation models can be developed. For example, the hybrid strain H-23, generated by mating basidiospore-derived monokaryons from two commercial cultivars, had relatively high polysaccharide and triterpenoid contents as well as desirable biological efficiency, indicating that sexual crossing can integrate multiple favorable traits into new strains (Liu et al., 2017). In recent years, molecular breeding and high-throughput screening have further expanded breeding pathways. A new variety, GL_V2, obtained through ultraviolet mutagenesis, showed a 1.4-fold increase in total triterpenoid content compared with widely cultivated varieties and exhibited stronger antioxidant activity (Pan et al., 2025). Atmospheric room-temperature plasma mutagenesis combined with microdroplet cultivation technology can rapidly screen mutants with 17%~26% higher biomass and up to 32% higher triterpenoid production in liquid cultivation, with stability maintained over multiple generations (Feng et al., 2024). In addition, new strains obtained by combining genetic engineering with mono-mono crossing can significantly increase the contents of specific ganoderic acids, squalene, and lanosterol, providing new ideas for targeted improvement of active components in *G. lucidum* (Zhou et al., 2024).

The promotion and application of superior varieties are equally critical. At present, some regions still face problems such as non-standardized strain sources, strain degeneration, variety mixing, and insufficient coverage of superior strains, which affect production stability and product consistency. Therefore, standardized strain propagation systems and superior variety promotion mechanisms should be established, and variety registration, regional adaptability trials, strain quality testing, and market supervision should be strengthened. Research on developing *G. lucidum* as a "next-generation cell factory" also suggests that synthetic biology and pathway engineering may be used in the future to optimize the production of target products such as proteins, polysaccharides, and triterpenoids, although the complexity of regulatory mechanisms and the efficiency of genetic manipulation remain bottlenecks to be overcome. Therefore, the promotion of superior varieties should be integrated with facility-based production standards, regional environmental parameters, product uses, and quality evaluation systems, so that breeding outputs can truly serve the needs of large-scale, standardized, and high-value production (Liu et al., 2017; Tang et al., 2023; Feng et al., 2024; Wu et al., 2024).

7.3 Construction of *Ganoderma lucidum* branding and product traceability systems

As consumers increasingly focus on the quality, safety, and authenticity of health products, the *G. lucidum* industry is gradually shifting from traditional raw material sales toward branding, standardization, and high-value-added operations. Brand building can not only increase the added value of *G. lucidum* products, but also enhance consumer recognition and market competitiveness. A recent review on the standardization of the *G. lucidum* industry proposed that a whole-chain standard system should be established, covering germplasm and strain-type standards, cultivation and harvesting standards, processing standards, circulation standards, quality